Art. VI.—*The Bone Clay and Associated Basalts at the Great Buninyong Estate Mine.*

By T. S. HART, M.A.

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In the latter part of 1897 certain fossil bones were discovered at the Great Buninyong Estate Mine, a number of which came into my hands through the Hon. R. T. Vale, Chairman of Directors. Others I collected myself. The bones have been submitted to Mr. C. W. De Vis, of the Queensland Museum, whose notes on them are now presented with this. One of those obtained by Mr. Vale showed evidence of human action in shaping it. This bone and others have already been exhibited to the Society.

It remains for me to describe the occurrence of these remains, and to offer some observations on the district.

The locality has been geologically mapped and described by Mr. R. A. F. Murray.[1] I shall have later to refer to certain differences in the lava streams and boundary lines between them not indicated by him.

The Mine.—The mine is situated about 1½ miles south of Buninyong railway station, and was intended to work the supposed continuation of the Devonshire and Union Jack leads, which had been worked some years ago. The workings had stopped from the No. 8 shaft soon after the date of Mr. Murray's report on the district, in which report the workings of the mine were described.

The lead is now covered by basalt, of which there are said to be two flows. The No. 1 shaft of the present company was sunk near the east edge of this basalt, but passed through a thickness of 143ft., in which there are said to have been two flows recognised, but the present manager, who took charge at 89ft. from the surface, says that the junction, if there are two flows, is above that point. From 143ft. onward the shaft con-

[1] Geological Survey of Victoria, Progress Report No. 1.

tinued in the Ordovician bed rock. An upper level at 200ft. passed into a stratified black clay with much carbonaceous matter. The lower level at 320ft. passed at a distance of about 360ft. from the shaft into a tumultuous mass of volcanic ejectamenta, containing large blocks of basalt and a smaller quantity of blocks of the bed rock. The deposit is quite unstratified in this level. The largest block is said to have measured 20ft. in length. The contact with the bed rock on both sides of this deposit is inclined inwards and blocks of the bed rock are commoner near the north-west contact. From this level a rise was made which passed into the black clay at 238ft. below the surface, and was connected by a drive on an incline to the upper level. At the top of this rise the first bones were found, viz., part of the head and lower end of the left humerus of Macropus faunus, as explained in Mr. De Vis' notes. The remainder of the bones were found in the connecting drive, which was driven from the rise towards the upper level. All the bones as found contained much pyrites, as did also the black clay in which they were found. This was more evident before treating them with size to preserve them. Parts of the hind limbs of two individuals and a skull of one were taken out by myself from the sides of this drive.

The clay beds dipped irregularly at low angles for the most part, and at the junction with the bed rock dipped from the line of contact. There were numerous surfaces of motion in the clay, and nearly all the longer bones were much fractured when first found in the clay, but usually with the pieces in their proper relative positions—showing that the fracturing was due to causes affecting them after burial.

A similar deposit was struck in another rise from the lower level. An intermediate level from this rise was driven north-easterly to a distance of 620ft. in a direct line at a depth of 295ft., or 25ft. above the bottom level. This for the greater part of its length showed interstratified sedimentary and volcanic materials, with blocks which had evidently fallen on the soft beds, disorganising the coarser ones and fracturing or bending the finer ones. No recognisable organic remains

were found here. A similar deposit may have existed in the other earlier rise between the ejectamenta and the black clays, being concealed behind the timber.

The beds in this 295ft. level were somewhat undulating, but not so disturbed as in the upper level.

At the end of this level, after passing out of the volcanic material, a rise revealed the presence of a similar material, with the line of contact dipping northerly, as if to a second hollow.

From the bottom level a small gutter was found and worked till it stopped abruptly against the volcanic ejectamenta, close to the boundary of the same material in the bottom level and at a height of 55ft. above it. I did not see this, as work was immediately stopped and the ventilating pipes withdrawn, the mine being closed in a few days. The volcanic ejectamenta then occupy a hollow in the bed rock 390ft. in one direction. They are overlain by mixed volcanic and sedimentary material, the volcanic materials becoming very much less in upper levels and the ejected blocks ceasing altogether. The whole range in height proved is from less than 200ft. below the surface to below 320ft., *i.e.*, over 130 feet.

The second deposit of volcanic ejectamenta at the end of the intermediate level seems to be the same as met with in the old No. 8 workings, and described by Mr. Murray. The two may be connected with one another, though separated as seen in the drive.

Mr. Murray suggests that the deposit at the No. 8 is a volcanic outlet pipe. In that case a dyke of basalt was also found.

Such an explanation would account for the abrupt termination of the wash against the side of the volcanic materials in this mine. There is no evidence, however, of great heat in this case, and the materials resemble an ordinary subaerial accumulation of volcanic ejectamenta. The large size of the blocks would indicate proximity to the vent, and the actual vent may be in the immediate vicinity, though not exposed in the workings. The presence of ejected blocks in little disturbed beds above would require subsequent activity of another vent.

Another possible explanation is that the abrupt conclusion of the wash is due to subsequent movement and a lowering of the volcanic materials bodily. The slight disturbance of the clay and ash beds in the intermediate level, and the greater disturbance and apparent drag at the boundary of the Ordovician, would favour this, though the superincumbent weight of basalt might account for much movement and compression of the underlying soft material. The occurrence at the No. 8 workings of a lead dipping both ways also indicates changes of relative levels. If that lead falls north naturally to the Devonshire lead, it would indicate a subsidence to the south.

The abrupt conclusion of the wash and the position of the ejectamenta are then referable either to an actual vent, and succession of vents, or to local subsidences in the neighbourhood of a volcanic vent.

The depth of the bottom level does not preclude the possibility of a valley with an outlet to the Yarrowee lead existing below it, even apart from any movement. The surface level is here 1337ft. above sea level, and the bottom level 1017ft. At the No. 3 shaft of the old company the surface level is 1227ft. and the main gutter 280ft. below, or 947ft. above sea level.

Surface Materials.—The surface directly over the mine, is a basalt strip, which extends from Buninyong southward and slightly westward, to the south-west corner of the Buninyong Estate. It is bounded on the east, through the Buninyong Estate, by the Devonshire Creek, which nowhere crosses it on the surface. The surface of the basalt is somewhat uneven, but has a general and considerable fall of almost 100ft. to the mile southward. East of the creek the surface is for the most part Ordovician, more or loss covered by recent alluvium, but to the south-east of the No. 1 shaft is a hill marked by Mr. Murray as a point of eruption and known as Webb's Hill. From it two spurs run to the north-west and west, covered by volcanic ejectamenta, in which blocks of the Ordovician bed rock, usually micaceous, predominate on the north-west spur. On the other is an outcrop of vesicular lava, perhaps a dyke. There is no visible olivine present in any of the vesicular lavas and scoria on this hill, which is in striking contrast to the

Buninyong basalt stream and to that on Mount Buninyong itself, in which olivine is extremely common, particularly in vesicular materials.

Webb's Hill and these two ridges would seem to represent the remnants of an old volcano. The extension of the volcanic material to the west would naturally be expected to occur under the Buninyong basalt, and the volcanic ejectamenta there found with these surface materials, perhaps represent successive eruptions from different vents. The present disposition of the surface volcanic material would favour a vent nearer Webb's Hill, or between it and the No. 1 shaft.

At the south-west corner of the Buninyong Estate the lava streams are easily distinguishable into three, differing in appearance, usually in a very marked degree.

In the bed of the Yarrowee Creek is a dark, compact lava, with much porphyritic augite and little olivine visible, which agrees with Messrs. Murray and Etheridge's description of what they name the Durham Lead flows[1]. It appears to be their Upper Durham Lead flow. It is seen higher up at Scotchman's Creek, but further I have not investigated its continuation. It extends down the Durham Lead below. Similar basalt occurs in the blocks in the ash on the north spur from Webb's Hill and in the ejectamenta of the No. 1 workings.

Overlying this on both sides of the Yarrowee Creek is a paler and coarser textured lava, without any visible olivine or porphyritic minerals, and similar to that which occurs on the western volcanic area of Ballarat—subsequently referred to as the Yarrowee lava. This appears to be close to its southern end, and not extending much further. The Buninyong lava stream is characterised by the extreme abundance of olivine, often in large lumps of 2in. or more diameter in the vesicular portions. This character is found invariably from the township across Buninyong Estate to a low bank running parallel to the Yarrowee at the west side of the Buninyong Estate and another low bank near the mouth of the Devonshire Creek, both marked on Mr. Murray's map. Between these it reaches the Yarrowee for a short distance, but never crosses it.

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1 Geological Survey of Victoria, Progress Report No. 2.

Beyond both these banks the Yarrowee type is found, and also on the other side of the Devonshire Creek, at its mouth. The actual contact is nowhere seen, being always concealed by soil, but blocks *in situ* on the Devonshire Creek west bank above No. 3 shaft are, though decomposed, most like the Yarrowee type. At the No. 3 shaft the Durham Lead type is most common, but the accessible surface excavations are in the Buninyong basalt. The Yarrowee type also occurs here, probably from the shaft.

It is easily seen that the Yarrowee flow overlies the Durham Lead flow, and the disposition and amount of denudation of the two makes it certain that the Buninyong overlies the Yarrowee flow, independently of the somewhat doubtful superposition in the Devonshire Creek. The lava flows from Buninyong would, therefore, be the newest, and from the amount of erosion which they have undergone, need not be of any great age.

The height of the basaltic plain above the creek varies, but only at two places does it exceed that close to the No. 1 shaft, viz., about 30ft. These are at a short distance before its junction with the Yarrowee Creek and at a point at the south boundary of the township, where the Devonshire Creek, coming from the ranges to the east, first meets it, and is deflected southward. There is nothing to indicate that any appreciable portion of the basalt has been removed by denudation—indeed, near the No. 1 shaft and near the mouth of the creek this could not have been so. At the Devonshire shaft east of the creek, near the No. 8 shaft, 40ft. of basalt was passed through, under 70ft. of drift and clay. If this is from Buninyong, it is not the present surface basalt.

The area in which the bones occur would almost necessarily be a lake or swamp, with the present relative levels, as the bottom of the basalt is about 1195ft. above sea level, and this is very little above the present level of the Yarrowee Creek, whose course can only have been very slightly affected by the Buninyong basalt, and must have been higher than at present.

On the other hand a very considerable time probably elapsed between Yarrowee and Buninyong flows, and also very likely between the Durham Lead and Yarrowee flows.

It would also be evident that the period of activity of Webb's Hill is much older than that of the Buninyong lava stream here dealt with. The erosion previous to that flow of lava was probably considerable, and now the materials on the surface would appear for the most part to represent the older ejectamenta of that hill. From the period of activity and similarity of lava it may be that Webb's Hill and the vents now buried are contemporaneous, and perhaps connected with the Durham Lead lava, for which Messrs. Murray and Etheridge suggest a source near Buninyong.

We have, then, that there is represented in the locality an earlier period of volcanic activity to which we may refer Webb's Hill, the ejectamenta in the mines, and the Durham Lead and Yarrowee flows. The black clay beds accumulated subsequently to these in a swamp or lake until covered by lava streams from Buninyong. There need not have been any considerable lapse of time since this, so that the bones are referable to a comparatively recent period.

In conclusion, I must express my thanks to the Hon. R. T. Vale and Mr. N. Kent, the mine manager, for the assistance and facilities given in examining the mine and collecting fossils, and also for plans of the workings; to Mr. De Vis, for the valuable discussion of the authenticity and identification of the bones; and to Mr. R. J. Allen, engineering assistant at the Ballarat School of Mines, who undertook certain surveys and levels; and to those who have at various times assisted me in the collection of fossils, and in other ways.